RADIO *Shop* MANUAL

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S/S Mobiloil

TESTING AND REPLACING PARTS

ERM-4

NATIONAL SCHOOLS
LOS ANGELES CALIFORNIA

MAKE it your mission... to render service to others, & you shall find that you are rendering the greatest service to yourself.

J. A. ROSENKRANZ

RADIO Shop MANUAL

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TESTING AND REPLACING PARTS

Replacing defective radio parts is mostly a matter of obtaining either an exact duplicate or of selecting a substitute of standard manufacture that can be installed correctly in the space alloted to the original part.

Special tuning devices (particularly automatic tuning mechanisms), coil assemblies for all-wave receivers, dial assemblies and parts thereof--and miscellaneous accessories which are distinctive of some particular make and model of receiver -- cannot usually be replaced by so-called standard parts. Other items such as filter condensers, power transformers, bypass condensers, audio transformers, chokes, resistors, etc., can nearly always be replaced with standard parts.

In fact, a great many manufacturers, wherever possible, employ standard parts which can be obtained from any radio supply house. This aids greatly toward solving the replacement problem in that a stock of special parts need not then be kept on hand.

When it becomes necessary to replace complete assemblies or certain parts of such assemblies, for which standard substitutes cannot be used, the only recourse is to purchase the parts required from the nearest dealer or distributor of the particular make of receiver which is being repaired. If no distributor is located within a reasonable distance from you, order the replacement part direct from the receiver manufacturer.

A serial number or order number is stamped on some special parts, and this number must be given in the order to the manufacturer. In cases where an order number cannot be found on a part, it can usually be located on the parts list appearing in an instruction booklet or sheet which is generally included in the packing case in which receivers are shipped, or else fastened to the inside wall or bottom of the receiver cabinet.

Sometimes, it is a great help to the Parts Department of a large manufacturing company to send the defective part along with the order for its replacement. In all cases, the name and model number of the receiver should be specified, and any other information given which may seem necessary to obtain the correct replacement.

REPLACEMENT POWER TRANSFORMERS

When confronted with the job of replacing a defective power transformer, we must determine what type of replacement transformer can be employed in that particular receiver, and the voltage and current ratings required.

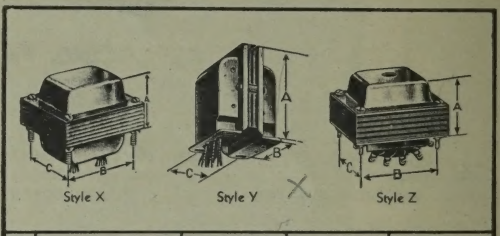
At the top of Fig. 1 are shown three standard types of replacement power transformers, which are classified as styles X, Y and Z by one particular manufacturer. Other manufacturers may use different letters, numbers, a combination of numbers and letters, or even names to identify these three basic structures and methods of mounting.

Styles X and Y in Fig. 1 are representative of the greater percentage of power transformers employed in receivers of recent design. The style Z transformer was used in quite a number of the older receivers.

The table presented in Fig. 1 is typical of those furnished in catalogs published by transformer manufacturers and radio supply houses to assist the service technician in selecting a power transformer to best meet the requirement of some specific receiver or amplifier.

As you will notice in Fig. 1, the table is divided into five vertical columns. The first column at the left states the style of case and mounting corresponding to the values specified toward the right. The second column lists the a-c voltage and milliamperes of current furnished by the high-voltage secondary winding. The third column specifies the voltage and maximum current which can be supplied to the filament of the rectifier tube. The fourth column gives the values of voltage and allowable current drain for the other tubes employed in the receiver; and the fifth column specifies the dimensions of each transformer in the order of height (A), length (B), and width (C). The abbreviation "C.T." in this table designates that the winding in question has a center tap.

This table is based on transformers comprising two filament windings, and which are to be used in receivers employing 6.3-volt tubes in conjunction with a 5-volt rectifier. Similar



STYLE	HIGH VOLTAGE SECONDARY	SECONDARY FOR RECT. FILAMENT	SECONDARY FOR TUBE FILAMENTS	DIMENSIONS A - B - C
X	650 Volts C. T. 40 Mills	5 Volts 2 Amps.	6.3 V. C. T. 1.6 Amps.	3x2½x2¼
Y	650 Volts C. T. 40 Mills	5 Volts 2 Amps.	6.3 V. C. T. 1.6 Amps.	3⅛x2⅝x2⅛
Z	650 Volts C. T. 40 Mills	5 Volts 2 Amps.	6.3 V. C. T. 1.6 Amps.	3x2½x2
X	700 Volts C. T. 50 Mills	5 Volts 2 Amps.	6.3 V. C. T. 2 Amps.	3x2½x2½
Y	700 Volts C. T. 50 Mills	5 Volts 2 Amps.	6.3 V. C. T. 2 Amps.	3⅛x2⅝x2¾
Z	700 Volts C. T. 50 Mills	5 Volts 2 Amps.	6.3 V. C. T. 2 Amps.	3x2½x2¼
X	700 Volts C. T. 60 Mills	5 Volts 2 Amps.	6.3 V. C. T. 2.5 Amps.	3x2½x2¾
Y	700 Volts C. T. 60 Mills	5 Volts 2 Amps.	6.3 V. C. T. 2.5 Amps.	3⅛x2⅝x3
Z	700 Volts C. T. 60 Mills	5 Volts 2 Amps.	6.3 V. C. T. 2.5 Amps.	3x2½x2½
X	700 Volts C. T. 75 Mills	5 Volts 3 Amps.	6.3 V. C. T. 3.2 Amps.	3⅜x2-⅝x3
Y	700 Volts C. T. 75 Mills	5 Volts 3 Amps.	6.3 V. C. T. 3.2 Amps.	3½x2-⅝x3⅛
Z	700 Volts C. T. 75 Mills	5 Volts 3 Amps.	6.3 V. C. T. 3.2 Amps.	3⅜x2-⅝x2⅝
X	750 Volts C. T. 125 Mills	5 Volts 3 Amps.	6.3 V. C. T. 5 Amps.	3¾x3⅛x3¼
Y	750 Volts C. T. 125 Mills	5 Volts 3 Amps.	6.3 V. C. T. 5 Amps.	3⅞x3⅜x3⅜
Z	750 Volts C. T. 125 Mills	5 Volts 3 Amps.	6.3 V. C. T. 5 Amps.	3¾x3⅛x3⅞

FIG. 1
TYPICAL POWER TRANSFORMER TYPES AND SPECIFICATIONS

specifications will be given in the manufacturer's descriptive catalog for transformers that are to be used in receivers employing tubes rated for other filament voltages.

HOW TO SELECT A REPLACEMENT POWER TRANSFORMER

To illustrate the handling of such problems, let us analyze the procedure for selecting a power transformer which is to be used in a 110-volt a-c receiver employing the following tubes: 2-6K7's, 1-6A8, 1-6H6, 1-6F5, 2-6F6's operating as Class-A pentode power amplifiers, and 1-80 rectifier.

Naturally, we first examine the damaged power transformer, noting its style and general dimensions. Then we proceed to determine the voltage and current which each of the transformer's secondary windings will have to supply, and also the voltage of the power line across which the transformer's primary winding is to be connected.

DETERMINING HIGH-VOLTAGE WINDING REQUIREMENT: The usual plate voltage required by 6F6 output tubes operating under Class-A conditions is around 250 volts. The maximum-signal plate current of each of these tubes at this voltage is 35 ma., and the maximum-signal screen current is 9.7 ma. Thus, the total maximum plate and screen current for two of these tubes is (35 + 9.7) x 2 or 89.4 ma.

Now, it must be remembered that maximum-signal plate and screen current values were used in determining the total B current drawn by the output tubes at the peaks of signal voltage. The average plate and screen current values during the operation of this receiver will be somewhere between the no-signal and the maximum-signal screen values. The no-signal plate and screen current for a Class-A operated 6F6 tube is approximately 34 ma. and 6.5 ma., respectively -- which constitutes a total cathode current of 40.5 ma. per tube, or (2 x 40.5), or 81 ma. for the two tubes.

From these figures it will be noted that there is a difference of 8.4 ma. between maximum-signal and no-signal conditions. Thus, the average operating conditions of the output tubes will require a cathode current of 81 plus one-half of 8.4 or 85.2 ma.

Obviously, there is not a great difference between the zero-signal and maximum-signal current requirements of type 6F6 tubes when operated as Class-A pentode amplifiers, and therefore allowance for these factors is not critical in this particular case. However, in some output stages employing class-B amplifiers, or modifications thereof, there is a much greater difference between the no-signal and maximum-signal B currents -- and this fact must then be given due consideration in determining the current demands of the transformer's high-voltage secondary winding.

While it may be desirable to use a power transformer which will exceed the average-signal requirements as to high-voltage current capabilities, it is nearly always very difficult to do so, as the increased size of such a transformer usually makes it impossible to mount it in the same space occupied by the old one.

Under ordinary conditions, the average combined plate and screen current for a 6K7 tube is around 9 ma., or 18 ma. for the two tubes used in this receiver. The total cathode current for a 6A8 tube is approximately 10 ma., and that for a 6F5 tube is about 1 milliampere. No current is required for the 6H6, as it is not connected to the high-voltage circuit.

The total plate and screen current for all tubes then amounts to 85.2 + 18 + 10 + 1 or 114.2 ma. However, this does not take into account

the flow of bleeder current through the voltage divider network in the receiver. Taking the highest average value of bleeder current (10 ma.), and adding it to the total plate and screen current value, we arrive at 124.2 ma. as the total current to be supplied by the transformer's high-voltage winding.

Since the tubes used in this receiver call for a filament voltage of 6.3 volts, we can use the table given in Fig. 1 to select the replacement transformer. Upon looking through the second column of this table for a transformer which has a high-voltage winding capable of supplying 124.2 ma., we find that the highest current rating listed here is 125 ma. (or 125 mills). Therefore, insofar as the high-voltage winding is concerned, we could use either one of the last three transformers listed in this table. Notice, also, that the secondary voltage of this winding in all three of these transformers is adequate to meet the requirements of a receiver using the tubes specified.

DETERMINING LOW VOLTAGE WINDING REQUIREMENT: The next step is to determine the voltage and current ratings for the windings that are to supply the filament energy for the tubes.

An 80 rectifier operates at a filament voltage of 5 and draws a current of 2 amperes. Therefore, either one of the 125 mill transformers listed in Fig. 1 will meet this requirement.

All of the remaining tubes of our receiver need a filament voltage of 6.3, and the filament current drawn by them is as follows:

The 6K7's, 6A8, 6H6, and 6F5----------0.3 amp., each
The 6F6's----------0.7 amp., each

The total filament current thus amounts to (5 x 0.3) + (2 x 0.7), or 2.9 amps. The 6.3-volt filament windings on all three of the 125 mill transformers in Fig. 1 have a current-delivering capacity of 5 amperes; and, therefore, either one of them will be more than able to supply the filament current demanded by this receiver.

MOUNTING REQUIREMENTS: The physical size and shape of the replacement transformer selected should conform sufficiently to that of the old one so that it can be mounted satisfactorily in the space allowed for it on the chassis. The type of mounting selected should, of course, also be such that the transformer can be fastened to the chassis conveniently.

When necessary, additional holes can be drilled in the chassis to match those of the transformer-mounting -- and machine screws with nuts, or self-tapping screws, used as the means of attachment.

When selecting transformers corresponding to styles X and Z in Fig. 1, you must also note whether or not the large hole or window in the chassis is large enough to permit the terminal strip (or its enclosure) to pass through it freely. In certain cases, it might be necessary to enlarge this opening somewhat.

Sometimes, if the original transformer corresponds to style Z in Fig. 1, it is possible, when necessary, to replace it with either a style X or style Y transformer; provided, of course, that adequate provisions are made for mounting the replacement unit in a satisfactory manner. In this respect, a style X transformer is more suitable as a substitute for the style Z than would be the style Y transformer.

CONNECTING THE NEW TRANSFORMER

Connecting the new transformer to the receiver circuits is often confusing to the average beginner, especially when the corresponding leads of the replacement unit differ in color from those of the original transformer, or when the terminal arrangements are not alike.

The leads of most replacement power transformers are color-coded according to standards prescribed by the Radio Manufacturers Association (R.M.A.). This color code is as follows:

Primary ----------Both leads, black.
(If primary is tapped, black is the start or common lead; black and red striped is the finish lead, and black and yellow is the tap lead).

Rectifier Plate Winding ----------Both leads, red.
(Center tap is red and yellow striped.)

Rectifier Fil. Winding ----------Both leads, yellow.
(Center tap is yellow and blue striped.)

Fil. Winding No. 1 ----------Both leads, green.
(Center tap is green and yellow striped.)

Fil. Winding No. 2 ----------Both leads, brown.
(Center tap is brown and yellow striped.)

Fil. Winding No. 3 ----------Both leads, slate.
(Center tap is slate and yellow striped.)

Note: Many power transformers do not have filament windings Nos. 2 and 3.

Irrespective of any color coding that may be used for the various leads, replacement transformers are usually supplied with a diagram which shows the connection for each colored lead. This diagram or instruction sheet must be followed if the leads of the transformer are not color coded according to R.M.A. standards, or if you are not sure of the color code.

Be especially careful in cutting the leads to the proper length when connecting them to the receiver circuits. It is better to have them slightly longer than actually necessary, than to cut them to the exact length; as when a short lead is pulled tight, it may be broken loose from the transformer winding. Care must also be exercised when removing the insulation from the end of the lead which is to be soldered, so that the lead will not be pulled loose from its winding.

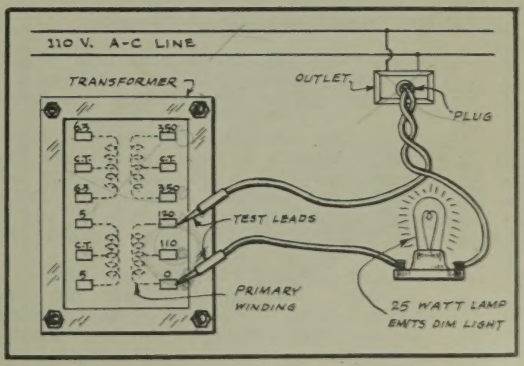


FIG. 2
LOCATING PRIMARY WINDING TERMINALS

The terminals of transformers of the type designated as style Z in Fig. 1 are often marked directly on the terminal strip by the manufacturer. But when this is not the case, a diagram will be supplied with the replacement, so that the serviceman can identify the terminals without difficulty.

HOW TO IDENTIFY POWER TRANSFORMER TERMINALS

In the event that the leads of a transformer are not color coded, nor its terminals marked, they can be identified by means of tests. The procedure is as follows:

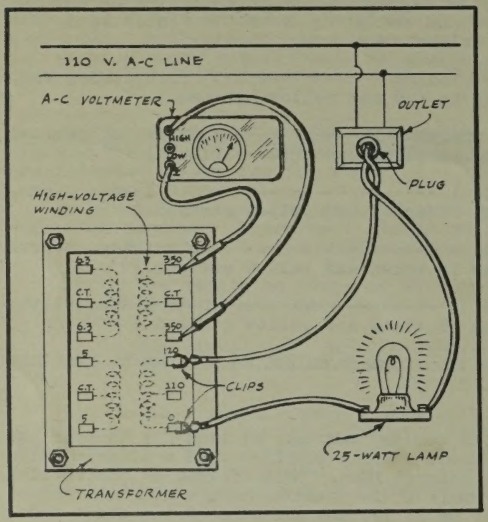


FIG. 3
LOCATING HIGH-VOLTAGE WINDING TERMINALS

1. Connect a 110-volt, 25 watt incandescent lamp in series with the 110-volt a-c lighting circuit and a pair of test points, as shown in Fig. 2. If it is a 220-volt transformer, use a 220-volt lamp.

2. Test between the various terminals until you locate a pair which cause the lamp to burn very dim. The primary winding will be connected to these terminals. (See Fig. 2)

3. Connect the lamp circuit across the primary terminals, and with an a-c voltmeter of suitable range test between the remaining terminals until readings corresponding to the high-voltage winding are obtained (see Fig. 3). If the high-voltage winding is designed for 700 volts, then a reading of this value will be obtained when the voltmeter is connected across the two end-terminals of this winding. A reading of one-half this amount will be observed if the voltmeter is connected between either end-terminal and the center-tap of this winding.

4. Using the low scale of the a-c voltmeter, continue testing for the terminals of the low-voltage windings. Remember that when testing between the center-tap of any of these windings and either end-terminal, the reading will be one-half that obtained when testing across the ends of the same winding. Also consider the transformer core as a terminal while testing.

5. If the primary winding is designed for both high and low line-voltage, the lamp will burn dim when one test point is held in contact with "zero" end of the primary and the other test point in contact with either of the two remaining primary terminals. However, the secondary voltages will be higher when the tap of the primary winding is used than when the two ends of the primary are corrected across the line. This fact aids in distinguishing the tap from an end-lead.

The procedure just described can be applied to all styles of power transformers --- irrespective of whether leads, terminal lugs or a combination of both are employed.

It is to be noted further that this same routine of testing can be employed also for the purpose of determining whether or not a power transformer is in working condition.

TESTING IRON CORE COILS

In a previous Shop Manual you were shown how testing the circuits of a receiver with a d-c voltmeter enabled you to determine whether or not a filter choke, audio transformer, speaker field, etc., is defective. In the event that either one of these parts is not connected to the receiver circuits at the time it is to be tested, you can check it in the following manner:

OHMMETER TESTS: Check the winding for continuity by connecting an ohmmeter across its terminals as shown at (A) of Fig. 4. If the ohmmeter indicates an infinite resistance (needle remains at extreme limit of maximum resistance on scale), the winding is open-circuited. If the ohmmeter indicates zero resistance, the winding is short circuited.

If the winding is in good condition, the ohmmeter reading will correspond to the resistance value of the winding specified by its manufacturer. This will be some definite value between zero and infinite resistance, which is usually stated on the circuit diagram of the more recent receiver models. If this information is not given on the circuit diagram, and coil manufacturer's specifications are not available, the ohmmeter reading will have to be compared with that for a similar unit of like manufacture which is known to be in perfect condition.

If the ohmmeter reading is lower than normal, the coil is only partially shorted; if the reading is much higher than normal, but not infinite, there is a poor connection in the coil circuit which should be investigated. The lug or lead connections should be inspected especially well in the latter case.

Also test the winding for a possible ground by connecting the ohmmeter between the iron core and one of the winding terminals as demonstrated at (B) of Fig. 4. An infinite resistance reading

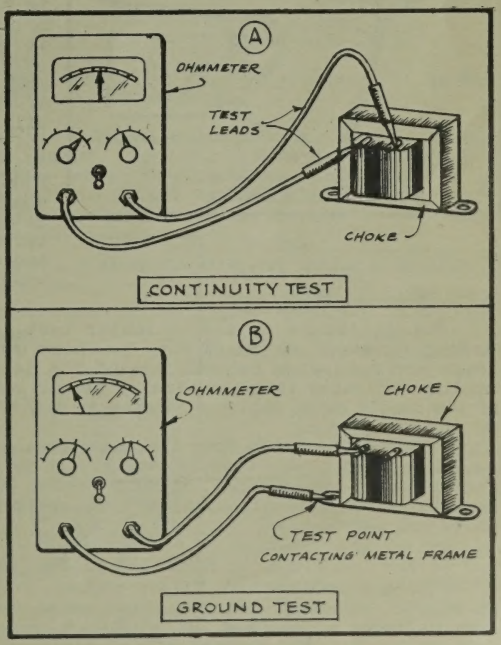


FIG. 4
TESTING IRON-CORE COILS WITH OHMMETER

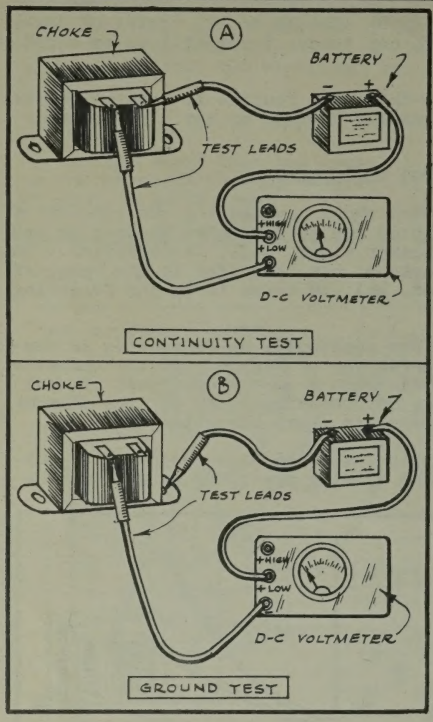


FIG. 5
TESTING IRON-CORE COIL WITH VOLTMETER

means that the winding is not grounded, while zero-resistance means that the winding is grounded at some point near the terminal to which one of the test leads is connected. Any reading between zero and infinity means that there is a ground, or leakage to ground, somewhere farther inside the winding. (Be sure that paint does not prevent the test point from making an effective ground connection).

VOLTMETER TESTS: The ohmmeter is considered as being the best method for checking windings for shorts, opens or grounds. But if no ohmmeter is available, a d-c voltmeter can be used in conjunction with a 4-1/2 volt "C" battery for the purpose. (Note: this voltage is not criticial --- either a lower or higher value may be used.)

This test is illustrated at (A) of Fig. 5, where the winding is being checked for a possible open circuit. If the winding is continuous (not open), when this test is made, the meter will read approximately battery voltage. If the winding is open, the meter will read zero.

This method does not usually furnish a reliable test for a shorted winding, as there will not generally be sufficient difference in the meter reading for a normal winding and one that is shorted so as to enable one to accurately distinguish between them.

The application of the voltmeter test, when checking for a grounded winding, is shown at (B) of Fig. 5. Here you will observe that the test leads are connected between one of the terminals and the core. A zero reading indicates that the winding is not grounded, while a deflection of the needle shows that the winding is either fully or partially grounded.

It is to be noted that the ohmmeter and voltmeter test just described can be applied to any winding, whether it be that of a choke, audio transformer, power transformer, speaker field, etc. However, it is important that the winding be disconnected completely from all circuits while these tests are made.

REPLACING FILTER CHOKES

Typical replacement filter chokes, for use in receivers, are shown in Fig. 6. Such chokes are often constructed in an open or unshielded form as those at (A) and (B) of Fig. 6, and are provided with connecting lugs or leads. The choke at (A) is designed for vertical mounting; that at (B), for horizontal mounting.

Small filter chokes are nearly always constructed in the form of those shown at (A) and (B).

Large filter chokes and swinging chokes are usually assembled in a case similar to those at (C) and (D) of Fig.6, and may be equipped with terminals or leads.

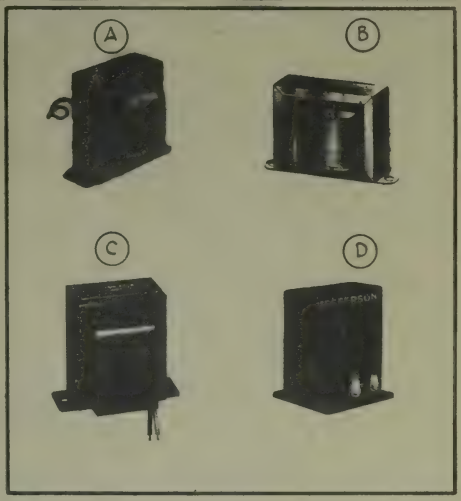


FIG. 6
VARIOUS STYLES OF FILTER CHOKES

SELECTING FILTER CHOKES: When replacing filter chokes, the following three factors are of primary importance:

1.- The required inductance value of the choke.
2.- The maximum current which the choke must handle.
3.- The d-c resistance of the choke.

Inductance, current-carrying capacity, d-c resistance and physical size are usually given in the manufacturer's catalog or bulletin in the form of tables similar to that shown in Table I.

If the required inductance value and current capacity are known, the proper replacement for a given receiver can be found easily be referring to such specification tables.

Observe in Table I that this particular manufacturer identifies each specific choke by a catalog number, and that the style of mounting is indicated by means of a number-letter combination. Illustrations appearing in the catalog will show in detail the type of mounting corresponding to each of the style numbers that are listed in the table.

TABLE I

FILTER CHOKE SPECIFICATIONS

FILTER CHOKES

Catalog No.	Style Mtg.	Rating Henries	Rating M.A.-D.C.	D.C. Resistance	Size
466-420	7A	15	30	515	2⅝"x1⅜"x1⅝"
466-490	7A	7	40	360	2½"x1⅜"x1½"
466-390	7A	20	50	425	3¼"x1⅜"x2"
466-590	Same as 466-390 but Sealed in Plastic				3¼"x1⅜"x2⅝"
466-230	7A	50	60	1400	4"x2½"x2½"
466-290	7K	50	60	1400	2⅞"x2⅝"x3⅛"
466-510	7H	50	60	1400	2⅞"x2⅝"x3⅛"
466-400	7A	8	80	245	3¼"x1⅜"x2"

SWINGING CHOKES

466-310	7K	20 to 7	20 to 70	250	2⅞"x1⅜"x2⅜"
466-190	7K	8 to 2.7	80 to 180	80	2⅞"x2⅝"x3⅛"
466-300	7H	6 to 3	120 to 200	75	2¾"x2½"x3½"
466-470	7Z	6 to 3.5	200 to 350	40	3⅝"x4½"x4⅞"

Notice further in Table I that the inductance values of these chokes are specified in henries; the d-c current handling ability, in milliamperes; and the d-c resistance, in ohms.

Sometimes, the inductance and current rating for the filter choke are specified on the circuit diagram or other technical literature furnished by the manufacturer of the receiver in question. But if this information is not available, the following suggestions might be of help to you:

To keep hum at a minimum level, filter chokes of high inductance are desirable

You will also find that chokes of smaller inductance can be used more satisfactorily with filter condensers of high capacity than with filter condensers of low capacity. Filter chokes ranging in inductance from about 15 to 30 henries are most used in the average home-radio --- the inductance of the choke being rated when carrying its normal current.

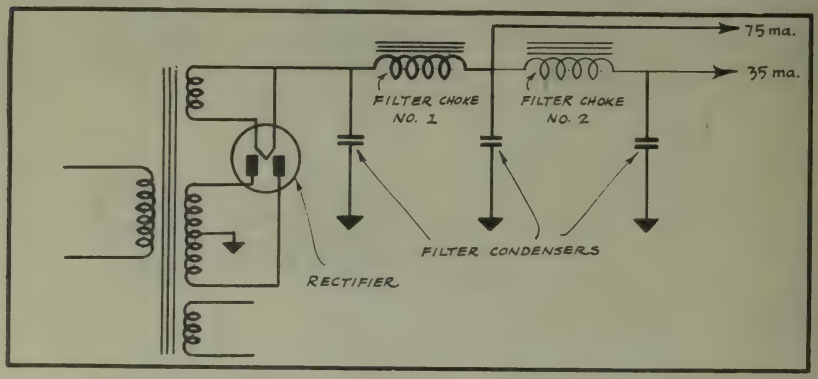


FIG. 7
ANALYZING CURRENT RATING REQUIREMENT OF FILTER CHOKES

Also, since chokes of high inductance and current rating are larger in size than those of lower rating, it is apparent that the physical dimensions of the old choke can to a certain extent be used as an index in ordering a replacement part of suitable electrical characteristics; furthermore, the replacement choke must be of such physical size as to fit in the chassis-space alloted to it. The column in Table I headed "Size" can be used to advantage in this respect.

To determine the current-rating of the choke, we follow a procedure similar to that outlined earlier in this Manual for calculating the total current requirements of a power transformer's high-voltage secondary winding. That is, we analyze the circuit of the receiver, noting how much current will flow through the filter choke under normal operating conditions.

For example, in a circuit such as that illustrated in Fig. 7, the total "B" current drawn by the receiver (75 plus 35, or 110 ma.) will flow through filter choke No. 1. Filter choke No. 2, however, will be expected to carry only 110 minus 75, or 35 ma. Therefore, in this particular circuit, filter choke No. 1 should be rated at not less than 110 ma., while filter choke No. 2 can be rated as low as 35 ma.

Obviously, the d-c resistance of these various chokes differs in accordance with their inductance and current-ratings. That is, a higher inductance calls for a winding of more turns and a corresponding greater length, which in turn increases the d-c resistance of the winding; while a higher current-carrying ability requires the use of a larger wire size, which reduces the d-c resistance.

Usually, the service technician is concerned primarily with the inductance and the current rating of the choke, and therefore orders the choke on the basis of these two values. He then considers the d-c resistance of the choke more as a factor of merit, figuring that a relatively low value of d-c resistance for a given value of inductance

indicates a high-quality choke. Conversely, a relatively high d-c resistance for a given value of inductance means that the wire used in the winding is of rather small size, which fact may cause the choke to overheat under full load. The d-c resistance of a choke that is not burned out can be measured with an ohmmeter.

SWINGING CHOKES: Swinging chokes, as listed in Table I, are used at the input of a filter system which is to supply a varying current to its load. This type of choke, and its placement in the circuit, improves voltage regulation of the B power supply --- which is essential in Class "B" and "AB" audio circuits. An example of a filter circuit employing a swinging choke is shown in Fig. 8, where you will note that this choke is used directly at the input of the filter in place of the usual condenser.

MOUNTING CHOKES: As in the case of replacement power transformers, dimensions of filter chokes must also be taken into account; however, the mounting space for a choke is generally not restricted so much as for a power transformer.

Filter chokes are nearly always mounted underneath the chassis, and the mounting holes for different chokes often vary considerably. Thus, in most cases, it is necessary to drill at least one new hole when installing the replacement choke. Self-tapping screws or machine screws with nuts can be employed to fasten the choke to the chassis.

AUDIO INPUT TRANSFORMERS

In modern receivers, the usual practice is to use interstage transformers only if push-pull output tubes are employed. Ordinarily, in such receivers, the input transformer serves to couple a single tube to two push-pull output tubes. However, in some of the larger receivers, push-pull driver tubes are coupled to push-pull output tubes. The use of more than one transformer-coupled stage is confined chiefly to transformer-coupled public address or so-called "sound" systems.

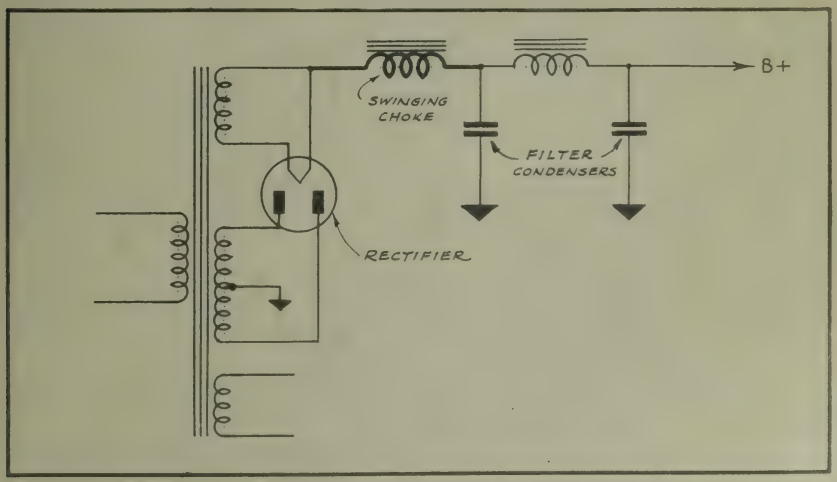


FIG. 8
APPLICATION OF SWINGING CHOKE

Output transformers are generally mounted on the speaker frame. However, in many receivers, particularly those employing permanent-magnet speakers, the output transformer is often mounted on the receiver chassis.

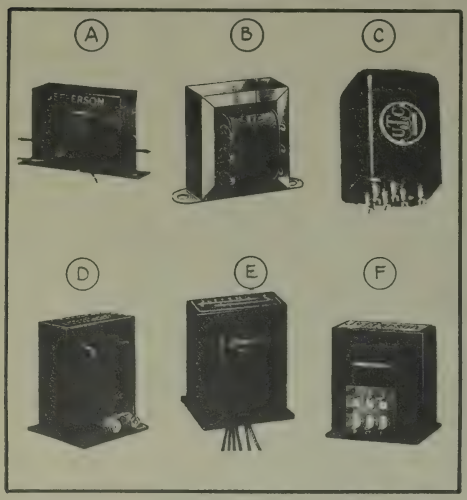


FIG. 9
TYPICAL AUDIO TRANSFORMERS

Several different styles of audio transformers are shown in Fig. 9. Observe the variations in structural features, terminal or lead arrangements, etc. The transformer at (C) is unique in that the terminals are at the bottom so that the various circuits can be connected to it conveniently underneath the chassis.

SELECTING INPUT TRANSFORMERS: The replacement of an input transformer is dependent on several factors, the most important of which are: (1) The application of the transformer--that is, whether it is to operate from a single plate into a single grid, from a single plate into push-pull grids, or from push-pull plates into push-pull grids; (2) The plate impedance of the driver tube or tubes; (3) The ratio of primary turns to secondary turns; (4) The operating condition of the output tube or tubes.

The proper selection of an input transformer is sometimes rather confusing because for the ordinary type of receiver in which power output and extreme high quality is not of fundamental importance, the input transformer will be listed in the supply store catalog simply as an "audio input transformer".

Usually, however, where better performance is to be expected from the transformer, the primary impedance and ratio of primary turns to secondary turns will be specified if the transformer is designed to couple a single plate to a single grid; or else the ratio of primary turns to one-half of the secondary will be given if the transformer is designed to couple a single plate to push-pull grids. Sometimes, the impedance values of the primary and secondary windings are given, and also the current rating for the primary winding.

Typical manufacturer's specifications for coupling a single plate to a single grid, and also a single plate to push-pull grids, are presented in Table II. A table similar to this is usually found in radio supply store and manufacturer's catalogs for selecting the better-class audio transformers.

In order to use Table II advantageously, the plate impedance of the driver tube must be known -- which value can be obtained by referring to a tube manual. The secondary winding impedances specified in this table are average values that are suitable in most cases. Notice further that the turns-ratio and permissible d-c current flow through the primary winding are also given in Table II.

If the structure of the replacement transformer is similar to one of those shown in Fig. 9, the mounting procedure is simple. Very often,

TABLE II

AUDIO INPUT TRANSFORMERS

SINGLE PLATE TO SINGLE GRID

From	To	Impedance Pri.	Impedance Sec.	Turns Ratio	D.C. Pri. M.A.
10,000 ohm plate	Grid	10,000	90,000	3:1	10
10,000 ohm plate	Grid	10,000	90,000	3:1	10
10,000 ohm plate	Grid	10,000	90,000	3:1	10
20,000 ohm plate	Grid	20,000	115,000	2.4:1	15
10,000 ohm plate	Grid	10,000	90,000	3:1	15

SINGLE PLATE TO PUSH-PULL GRIDS

10,000 ohm plate	P.P. Grids	10,000	90,000	3:1	10
10,000 ohm plate	P.P. Grids	10,000	90,000	3:1	10
10,000 ohm plate	P.P. Grids	10,000	90,000	3:1	10
20,000 ohm plate	P.P. Grids	20,000	180,000	3:1	15
10,000 ohm plate	P.P. Grids	10,000	90,000	3:1	15
10,000 ohm plate	P.P. Grids	10,000	90,000	3:1	10
10,000 ohm plate	P.P. Grids	10,000	40,000	2:1	15
10,000 ohm plate	P.P. Grids	10,000	90,000	3:1	15

however, a transformer of one style will be used to replace one of an entirely different style, in which case a change in the method of mounting may be required.

AUDIO TRANSFORMER CONNECTIONS

When connecting audio transformers having unmarked terminals to receiver circuits, refer to the connection chart which is nearly always supplied with such transformers. For instance, at (B), (D) and (F) in Fig. 9, each of the soldering lugs is numbered or lettered; and the instruction sheet of chart accompanying the unit will then inform you as to how these marked lugs are to be connected to the receiver circuits.

Sometimes, audio transformers have wire leads instead of soldering lugs for connection to the receiver circuits. In such cases, these leads will have insulation of different colors to aid in their identification. Usually, these leads are colored according to R.M.A. standards. The standard lead colors for transformers of this type are:

Green insulation.....grid lead
Black.....ground or bias lead (grid return)
Blue.....plate lead
Red.....plate supply voltage or B plus lead

Brown...Start lead of plate winding if primary is center-tapped.
Yellow..Start lead of grid winding if secondary is center-tapped.

Note: If polarity is not important, the brown and yellow leads may be blue and green respectively, in some transformers.

If the transformer terminals are marked B, P, G, and F, they are to be connected to the B+, plate, control grid and filament or grid-return circuit -- in the order here given.

In the event that the transformer terminals are not marked, and no instruction sheet on their connection

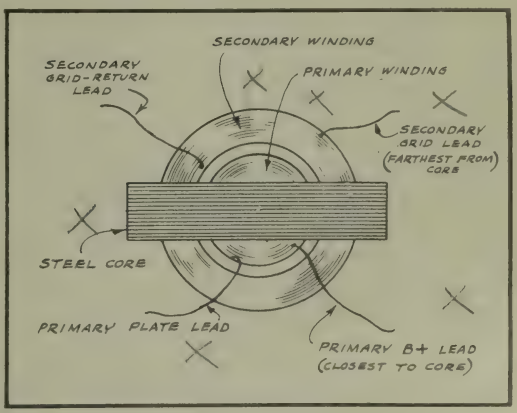


FIG. 10
RELATION BETWEEN WINDING LEADS AND CORE OF A-F TRANSFORMER

is available, you can then identify the terminals in the following manner:

First, examine the transformer and observe from which locality of the winding the various leads emerge. The inner coil is usually the primary and the outer coil the secondary, as illustrated in Fig. 10, where you are looking down upon the transformer from above. Therefore, the two leads which protrude from the coil nearest the center-leg of the transformer core are the ends of the primary winding, while those farthest from the core are the ends of the secondary winding. Furthermore, it is to be noted that the circuit connections to these leads should be made in accordance with their relation to the core as shown in Fig. 10.

The ends of transformer windings can also be located by means of simple continuity tests; or better still, with an ohmmeter. In the latter case, the ohmmeter reading will be higher when testing through the secondary winding than when testing through the primary. And, when testing between the center-tap and either end of a center-tapped winding, the reading obtained will be approximately one-half that obtained when testing between the ends of the same winding.

SELECTION OF HIGH-FIDELITY INPUT TRANSFORMERS

In some of the modern console receivers, considerable attention has been given toward attaining high-fidelity performance together with high power output. To make this possible, both the input and output transformers of the power amplifier stage must be precision-built.

In receivers of this type, the audio input transformer is usually called the "driver transformer" to differentiate it from an ordinary type. The primary impedance of such transformers matches exactly the plate operating conditions of the driver tube or tubes, and the secondary winding is designed to properly match the grid circuit impedance of the output tubes.

Typical specifications for driver transformers are given in Table III. Note that this table differs considerably from that for ordinary audio input transformers, in that the exact tubes are specified for which each individual transformer is designed. Thus, in selecting the proper replacement driver transformer for a "high-fidelity" receiver, all facts concerning the operation of the driver and output tubes must be known.

TABLE III

HIGH-FIDELTY AUDIO INPUT TRANSFORMERS

From	To	Class	Impedance Pri.	Impedance ½ Sec.	Ratio Pri. to ½ Sec.	D.C. Pri. M.A
P.P. 27, 37, 56, 76, 6C5, 30	P.P. 53, 6A6, 19	B	20,000	2,200	3:1	10
1-46, 45, 2A5, 6F6, etc. as Triodes	P.P. Grids 19, 79, 2A5, 6A6, 6F6	B	22,500	2,500	3:1	30
2A5, 30, 6A6, etc. as Triodes	P.P. Grids 19, 79, 2A5, 6A6, 6F6	B	10,000	2,500	2:1	30
1-42, 47, 2A5, Triode	P.P. 42, 2A5, 6F6	AB	10,000	10,000	1:1	30
1-27, 30, 37, 56, 76	1-19, 79	B	10,000	1,400	2.66:1	15
1-30, 49, 6C5	1-1J6G, 19, 2-30, 2-49	B	10,000	1,600	2.5:1	10
1-46, 42, 2A5, 6A6, 53, 30, 6L6, 2A3, 6A3, 6N7, 49, 59, 45, 37, 76, 6C6, 89, Triodes.	P.P. 46, 6A6, 59, 53, 1-19, 79, P.P. 46, 59, 2A5, 42, 45, 89	B	22,500	2,500	3:1	30
1-53, 79, 6A6, 6N7, 6E6, Triodes.	1-53, 6A6, 6E6, 6N7, 6N6-G, 89, 6L6, 6V6	B	25,000	1,000	5:1	15
1-30, 46, 6L6, 2A3, 6A3, 6N7, 49, 59, 45, 37, 76, 6C6, 2A5, 42, 89, Triodes.	1-19, 79, P.P. 46, 59, 2A5, 42, 45, 89	B B AB	22,500	2,500	3:1	40

For instance, the transformer corresponding to the first horizontal line of specifications in Table III is suitable for coupling two push-pull connected 27's, 37's, 56's, 76's, 6C5's, or 30's to a pair of 53's, 6A6's or 19's operating as Class-B amplifiers. The primary winding of this particular transformer has a rated impedance of 20,000 ohms, and each half of the center-tapped secondary winding has

an impedance of 2,200 ohms. The turns-ratio between all of the primary and one-half of the secondary is 3 to 1, and the primary winding is capabale of safely carrying 10 ma. of current.

The transformer described in the second horizontal line in Table III is designed for coupling a single triode-connected 46, 45, 2A5, 6F6, or similar tube to a pair of 19's, 79's, 2A5's, 6A6's, or 6F6's operating as Class--B amplifiers.

Thus, to order a transformer of this kind always specify the type number of the driver tube; whether a single or push-pull driver tubes are used; whether or not pentode driver tubes are connected in the circuit as triodes; the type number of the output tubes, their method of connection and class of operation. Or, refer to a manufacturer's specification sheet similar to that appearing in Table III of this Manual and order the transformer by its proper model number.

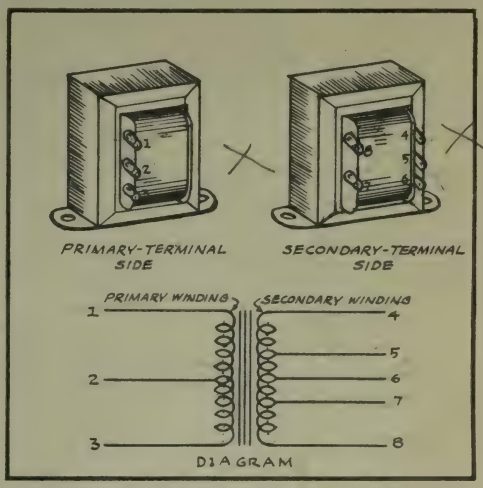


FIG. 11
UNIVERSAL OUTPUT TRANSFORMER

The transformer model or type numbers are not listed in Table III for the reason that we are not interested at this time in any particular make of transformer---but only with specifications as needed for ordering transformers of this kind from manufacturers in general.

AUDIO OUTPUT TRANSFORMERS

In the case of an output transformer, the load impedance of the power tube must be known; and the plate-to-plate load impedance, if the tubes are connected in push-pull. The voice coil impedance of the loudspeaker must also be known. In fact, the voice coil impedance must be accurately matched to the secondary impedance of the transformer; otherwise, considerable mismatch may occur in the plate load circuit. Most replacement output transformers have a tapped secondary winding so that they can be properly matched to practically any standard voice coil impedance.

UNIVERSAL OUTPUT TRANSFORMERS: In the case of "universal" output transformers, the secondary impedance of the transformer and the voice coil impedance of the loudspeaker are mismatched deliberately to a permissible extent. By so doing, the primary impedance of the transformer is altered automatically to provide the approximate load impedance required by the particular output tubes. Thus, the universal output transformer can be employed to match to a fair degree the load requirements of different singly-operated output tubes, or pairs of such tubes operating in push-pull; and therefore serves as a satisfactory replacement part in receivers of average quality.

The terminal arrangement and also the diagram for a typical universal output transformer are shown in Fig. 11. Here the primary terminals are numbered 1, 2, and 3 -- terminal No. 2 being the center-tap. The secondary

terminals are numbered 4, 5, 6, 7 and 8. (The two views of the transformer in Fig. 11 show the primary terminal strip on one side and the secondary terminal strip on the opposite side of the unit.) Data for connecting this transformer to various circuits is presented in Table IV.

TABLE IV

HADLEY UNIVERSAL OUTPUT TRANSFORMER

	Max. Watts	Pri. Ma. per side
D554	6	36
D556	10	45
D557	15	60

Pri. Load Impedance	2000	4000	5000	7000	8000	10000	14000	18000
	Single	Single	Single	Single	P.P.	P.P.	P.P.	P.P.
	48-2A3	45-71	43-59**	47-59*	43-45	42-6F6	47-59*	12A
		6L6	6V6	49-89*	71-6V6	2A5-6V6	49-89*	
				41-42	12A	6B5	41-42	
				6F6-2A5			6F6-2A5	
	Parallel	P.P.	P.P.	31-6B5		P. P. Class B	31	
	71A	48	2A3			53-6A6		
			6A3			6N7-19		
			6L6			79-89		
SEC. TAP	Voice Coil Impedance in Ohms							
7-8	.11	.22	.275	.38	.433	.55	.77	1.
6-7	.155	.31	.387	.55	.625	.79	1.1	1.41
4-5	.285	.575	.720	1.	1.14	1.44	2.	2.6
5-7	.375	.75	.94	1.31	1.50	1.89	2.62	3.38
4-6	.57	1.14	1.42	2.	2.28	2.88	4.	5.15
5-8	.9	1.8	2.2	3.13	3.57	4.5	6.25	8.1
4-7	1.	2.64	3.3	4.6	5.23	6.65	9.2	11.9
4-8	2.2	4.4	5.5	7.7	8.88	11.1	15.4	20.

*PENTODE **TRIODE

FOR SINGLE TUBE MATCH, USE PRIMARY 1-3. FOR PUSH PULL TUBE MATCH, USE PRIMARY 1-2-3. TO DETERMINE SECONDARY TAP, CHOOSE THE VERTICAL COLUMN CORRESPONDING TO THE CORRECT PRIMARY LOAD IMPEDANCE, AND SELECT THE SECONDARY TAPS THAT GIVE THE NEAREST VOICE COIL IMPEDANCE TO THAT DESIRED. FOR MAGNETIC SPEAKER WITH P.P. 71A USE 1-2 CONNECTION.

ROBERT M. HADLEY CO.

LOS ANGELES, CALIF.

Assuming that we are to use this transformer for coupling two 6V6 push-pull connected output tubes to a loudspeaker having a voice coil impedance of 8 ohms, we would proceed in the following manner:

First, we look for the number 6V6 in the upper section of the table, and in one of the columns headed P.P. (push-pull). This would be either the third or fourth vertical column from the right, but we select the latter because in the same column we also find at the bottom of the table a secondary (voice coil) impedance value of 8.88 ohms which is nearer to the required 8 ohms than any value in the next column toward the right.

Therefore, to satisfy these conditions, we would use terminals 1, 2 and 3 for the primary connections; and terminals 4 and 8 for the secondary connections. (See SEC. TAP column at left of Table IV).

If it is impossible to match the impedances exactly, it is advisable to work into a load of a higher rather than a lesser impedance. For instance, if 4 and 8 ohm taps are available on the output transformer, and the speaker impedance is 6 ohms, the 4 ohm tap should be used. This will result in only slight loss of power; whereas if the 8 ohm tap were used, the peak current of the power tubes would be excessive and distortion would occur.

If one has a sensitive sense of hearing, it is quite often possible to decide which pair of secondary terminals provide the best impedance match merely by tuning in a good musical program, and connecting first one and then the other pair of secondary terminals to the speaker voice coil. The pair that results in best tonal quality more nearly provides the correct impedance match.

28 C PMAH 69

HIGH-FIDELITY OUTPUT TRANSFORMERS: High-fidelity receivers should be supplied with output transformers of better quality and exact impedance match. This type of transformer will also usually have several secondary leads to permit accurate impedance matching with the voice coil of the speaker.

Specifications for certain output transformers are tabulated in catalogs and manufacturer's information sheets in a manner similar to that used for the listing of driver transformers. In selecting the proper replacement output transformer, it is usually necessary to know only the type of output tubes which are employed in the receiver, and the conditions under which they are being operated; and the impedance of the speaker's voice coil.

For example, it is possible to operate two 6F6 tubes as Class A, Class AB, or Class B amplifiers. A different plate load impedance is required for each of these different operating conditions Thus, before selecting the new transformer, the circuit connections and bias conditions of the output tubes should be checked, and the operating values checked against the tube manufacturer's specifications to determine if the tubes are being operated under Class A, Class AB or Class B conditions. Knowing this, it is then easy to select the correct transformer from the replacement catalog.

In Table V is shown as extract appearing in a transformer catalog prepared by the Thordarson Electric Mfg. Co. Here you will note that their type T-58S72 transformer can be used in the output circuit of two 2A3 or two 6B4G push-pull connected tubes operating under Class AB conditions. It can also be used in the output circuit of two 48 or two 25L6 push-pull connected tubes operating under Class A conditions.

Notice further that the secondary winding is tapped for properly matching this transformer to either a 4, 8 or 15 ohm speaker voice coil, or to a 500 ohm transmission line. The primary winding is rated to carry 60 ma. per side, and the transformer is capable of handling 30 watts of audio power.

TABLE V

HIGH-FIDELITY AUDIO OUTPUT TRANSFORMERS

Output Transformers to Line or Speaker

Type No.	Tube Type	Class	Ohms Impedance Pri.	Ohms Impedance Sec.	Pri. M.A. Per Side	Max. Watts
T-58S72	2-2A3 P-P	AB	3,000	4-8-15-500	60	30
	2-6B4G P-P	AB				
	2-18 P-P	A				
	2-25L6 P-P	A				
T-67S54	2-6L6 P-P	A	5,000	4-8-15-500	60	30
	2-2A3 P-P	AB				
	2-6B4G P-P	AB				
	2-45 P-P	AB				
	2-19 P-P Par.	B				

Similar data is given in Table V for the type T-67S54 transformer which is designed for use in the output circuit of certain tubes operating under Class A, Class AB or Class B conditions.

SELECTION OF SIZE: Physical dimensions for the ordinary type of replacement output transformer are usually not very critical when the transformer is to be mounted on the chassis; but, its dimensions are quite important when it is to be mounted on the speaker frame. The reason for this is that the method of mounting the original transformer

on the speaker frame usually leaves very little leeway for mounting the replacement. Either the new transformer must fit correctly in the space occupied by the old transformer, or else it must be mounted in a different manner.

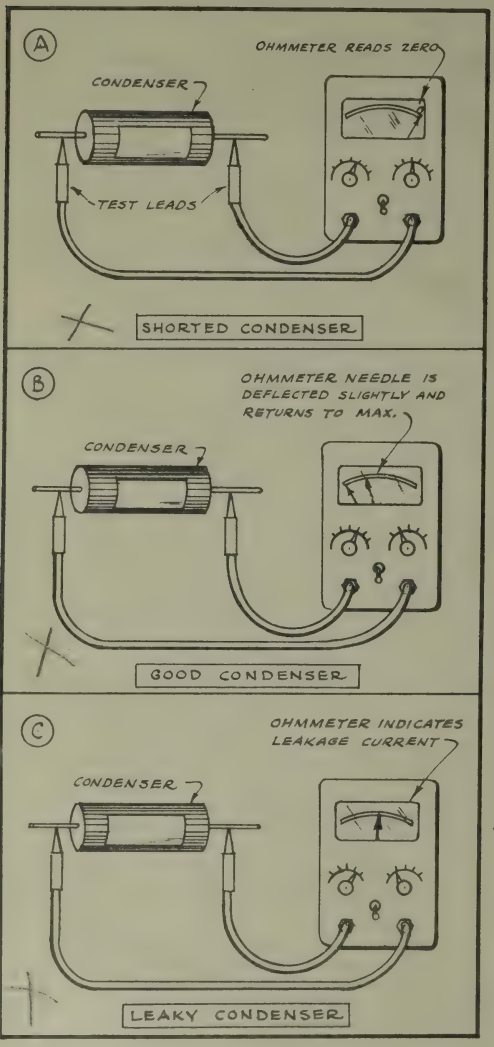


FIG. 12
TESTING CONDENSER WITH OHMMETER

The best policy, when replacing a speaker-mounted transformer, is to obtain an exact replacement from a distributor or from the manufacturer. This may require a little more time, but it often saves considerable trouble.

IMPORTANT:

It is to be noted that the transformer specification tables appearing in this Manual are not presented as a source of reference for selecting specific transformers, but solely for the purpose of informing you of the existence of such tables, and familiarizing you with their use. Therefore, they may not apply directly to some particular transformer in which you are primarily interested. For complete specifications on any transformer, refer to a manufacturer's catalog and apply the knowledge acquired from this Manual in making your selection.

TESTING SOLID-DIELECTRIC CONDENSERS

Condenser or capacitor testers--such as described in one of your regular lessons titled "Service Equipment" -- provide the most reliable means for checking the condition of ordinary mica and paper-dielectric condensers, as they are capable of checking the condenser for capacity value, leakage and other factors under actual working conditions. Procedures for doing this vary on testers of different manufacture; and since complete instructions are

always furnished with each particular make and model of tester, there is no object in our discussing them in this Manual.

OHMMETER TEST: Several alternative methods may be employed for testing such condensers if no condenser tester is available. One, is to use an ohmmeter in the manner illustrated in Fig. 12. It is important that the condenser be disconnected from all receiver circuits when this test is made.

If the ohmmeter reads zero resistance when connected across the condenser terminals, as at (A) of Fig. 12, the condenser is shorted and should therefore be discarded. If this test shows that the condenser is not shorted, make sure that the condenser is discharged by touching its leads together or shorting them together for an instant with a piece of wire or other suitable conductive material. When this has been done, contact the condenser terminals again with the ohmmeter's test points and watch the meter closely. If the condenser value is about 0.01 mf or larger, and the condenser is in good condition, the meter needle will be deflected slightly the instant that the test points make contact, and will then immediately return to the maximum resistance mark on the scale as at (B) of Fig. 12.

Should the meter needle indicate some definite value above zero, and fail to return to max., then the condenser is "leaky"--and the reading is the leakage resistance of the condenser. This is illustrated at (C) of Fig. 12.

If the needle isn't affected at all when the ohmmeter is connected across a condenser that has first been discharged, it indicates that the condenser is open circuited.

If condensers of smaller capacity than around 0.01 mf are tested by this method, a complete short or appreciable leakage will be easily observed on the meter, but the normal momentary deflection for a good condenser of very small capacity may not be of sufficient magnitude to be detected by the eye.

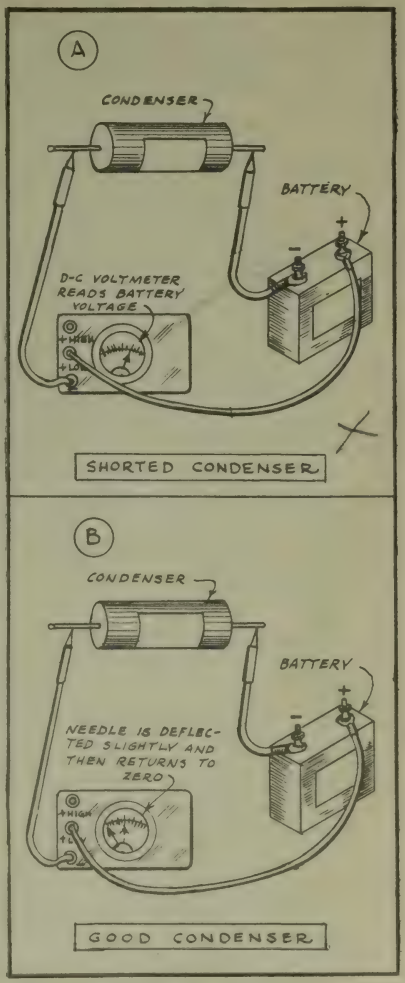


FIG. 13
CHECKING CONDENSER WITH D-C VOLTMETER

VOLTMETER TEST: Another simple condenser test is illustrated in Fig. 13. In this case, a low-range d-c voltmeter is connected in series with a 4-1/2

volt "C" battery (or other d-c voltage).

If the voltmeter indicates battery voltage when the test points are touched across the condenser terminals as at (A) of Fig. 13, the condenser is shorted. If the condenser is in good condition, and if of adequate capacity in relation to the battery voltage being used, the voltmeter needle will move slightly toward the right of the zero mark when the test points first make contact with the condenser terminals--but only for an instant. The needle will then immediately drop to zero, and remain there as long as the test points are held in place. (See B of Fig. 13).

NOTE: The condenser must be disconnected from the receiver circuit when this test is made. Also, be sure to first discharge the condenser by short circuiting it momentarily before applying this test.

HEADPHONE TEST: A rather elementary method of checking small mica and paper condensers is illustrated in Fig. 14. Here a pair of headphones are connected in series with a battery and the condenser being checked.

If the condenser is in good condition, and discharged, a click will be heard in the headphones when the test leads are first connected across the condenser terminals; and if the circuit is interrupted momentarily and then re-completed, the click will be fainter than before. The click will become fainter each time that the test is repeated, provided that the condenser leads are not short circuited between successive tests.

If the condenser is shorted, the click will be of the same intensity each time that the circuit is completed, even though the condenser is not discharged by shorting it between tests. The higher the battery voltage used, the louder will be the clicking sound. The battery voltage may vary from about 4-1/2 to 45 volts for this test.

Note: The condenser must be disconnected from the receiver circuit when this test is made.

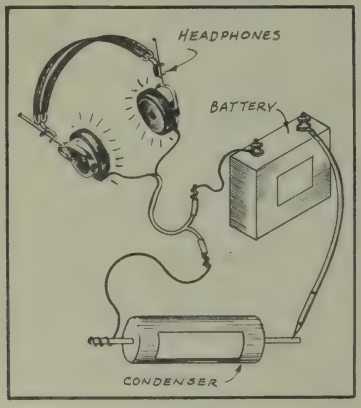


FIG. 14
CHECKING CONDENSER WITH HEADPHONES

FLASH TEST: The disadvantage of all of the condenser tests described thus far is that the voltage used for the test is considerably below that to which the condenser is subjected when installed in the receiver. Therefore, even though the condenser checks O.K. when subjected to one of these tests, it may still break down under actual operating conditions.

A simple test that takes this fact into account is illustrated in Fig. 15. To conduct such a flash test, the condenser is charged by momentarily connecting it across a source of B voltage which is approximately equal to the d-c voltage rating of the condenser being tested, as at (A) of Fig. 15. This B voltage may be furnished by a group of series-connected "B" batteries or by a suitable "B" power supply; in fact, it can also be obtained from the receiver being checked or from another receiver.

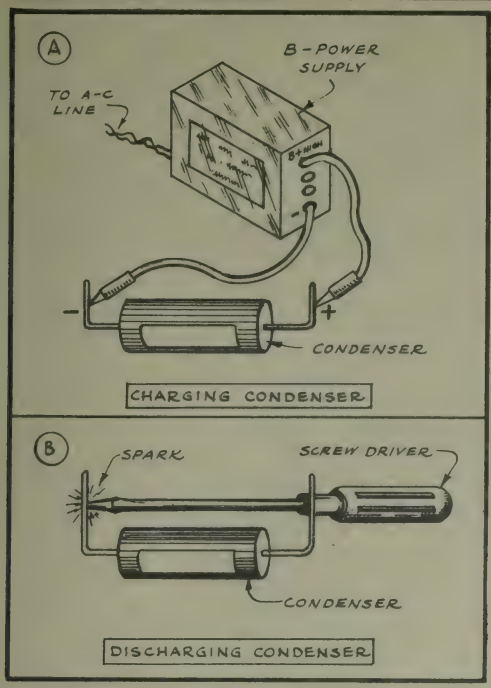


FIG. 15
CONDENSER FLASH TEST

After the condenser has been charged in this manner, it is short circuited by touching the blade of a screw driver--or any other suitable conductor--to both condenser terminals simultaneously, as at (B) of Fig. 15. A good condenser will produce a snappy spark when thus discharged.

It is to be noted further that condensers of larger capacity produce sparks of greater intensity when so tested, and that the spark produced by condensers of less than about 0.1 mf. capacity is hardly of sufficient intensity to make the test conclusive. Also, the longer the time that a condenser will hold a charge, the better is the condition of its dielectric. A good condenser may hold a charge for 10 minutes or more.

NOTE: The condenser must be disconnected from the receiver circuit when this test is made.

NEON LAMP TEST: A still better method for testing condensers is shown in Fig. 16. This set-up consists of an ordinary "B" power supply unit, with a 25,000 ohm adjustable wire-wound voltage divider resistor connected across its output. The clips are spaced along the resistance element and are connected to the contacts of a selector switch so as to make selection of the different available voltage values convenient. A neon lamp is used as an indicator.

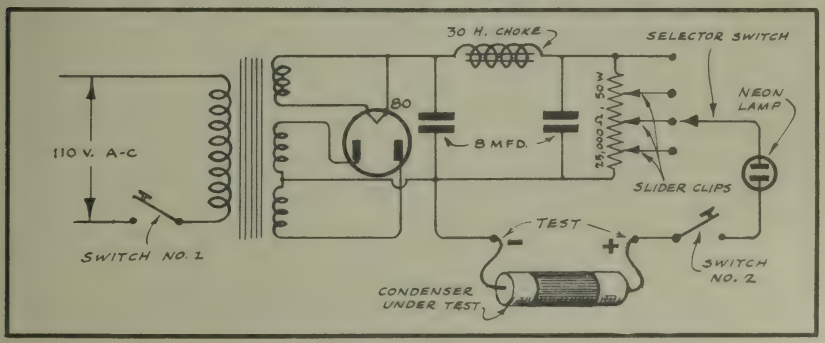


FIG. 16
NEON LAMP CONDENSER TESTER

To check a condenser on this tester, plug the tester into the 110 volt circuit, connect the condenser between the terminals labeled "test" (observing polarity where it applies), set the selector switch for the test voltage which is to be used (slightly below the d-c working voltage at which the condenser is rated), and close switch No. 1. After the 80 tube has warmed up, close switch No. 2, and observe the action of the neon lamp.

If the neon lamp flashes only once and emits no glow thereafter, you will know that the condenser is good. This momentary flash of the neon lamp occurs at the instant the condenser is accepting a charge. After the condenser is once charged, the voltage across its plates will oppose the applied voltage and thus prevent the further flow of current that is necessary to cause the neon tube to glow.

If the neon lamp glows continuously, the condenser is shorted. If the neon lamp blinks (glows intermittently), it indicates condenser leakage; and the condenser is in all probability not suitable for use. If the neon lamp isn't affected at all (that is, doesn't even flash during the supposedly intitial charging action), the condenser is open circuited.

TESTING ELECTROLYTIC CONDENSERS

The structural features and operating principles of electrolytic condensers are such that they will normally pass some leakage current when connected across a d-c voltage. Therefore, the condenser tests previously described are not reliable for testing condensers of this type.

OHMMETER METHOD: An ohmmeter can be used in an emergency to check small electrolytic condensers for a possible short circuit. When so doing, it is important that the condenser be disconnected from the receiver circuit ; and that the negative ohmmeter test lead be connected to the negative condenser terminal, and the positive ohmmeter lead to the positive condenser terminal. If the condenser is fully shorted, the ohmmeter will indicate practically zero resistance. The most reliable method, however, is to check such condensers for actual capacity value on a suitable condenser tester.

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LEAKAGE METHOD: The larger electrolytic condensers (dry or wet type) are checked on the basis of leakage, using the fundamental circuit presented in Fig. 17. To test electrolytic condensers by this means, the condenser is connected across a d-c voltage source of slightly less value than the d-c working voltage rating of the condenser to be tested. The voltage is adjusted to the value required by means of the variable resistance (rheostat) which is connected in the primary circuit of the high-voltage transformer.

Switch No. 2 is a non-locking, push-button type switch that is normally closed and short circuits the 0-5 ma. meter. Thus, this meter is protected against burn-out in the event that the leakage current of the condenser under test should exceed the full-scale reading of this instrument. The small lamp bulb acts as a protective fuse for all parts of the tester in case the condenser should break down completely at high voltages. Excess current flow through the lamp will of course burn it out, but this is an inexpensive part to replace.

With the condenser connected in the circuit and switches No. 1 and 2 closed, watch the behavior of the 0-200 ma. meter closely. If the current flow is rather high but not high enough to cause you to suspect the condenser of being defective, leave the condenser connected to the circuit for as long as 5 minutes so as to give it a chance to "age" in case that it hasn't been in use for some time. Continue this ageing process until the leakage current comes down to a stable value.

If the leakage current is now within the range of the 0-5 ma. meter, depress switch No. 2 so as to remove the short around the meter. This will permit accurate reading of the leakage current on the low-range meter.

If the leakage current is anywhere between 0.05 and 0.5 ma. per microfarad of condenser capacity, the condenser is considered to be useable. For instance, an 8 mf. electrolytic condenser may have a leakage current of from 0.4 to 4 ma. The greater the leakage current, the poorer is the condenser. Shorted or partially shorted condensers result in excessively high leakage current.

To accurately measure the capacity of an electrolytic condenser, check it on a suitable condenser (capacity) tester.

Leakage tests of small electrolytic bypass condensers having capacities of less than 1 mf. are unimportant. Capacity tests are more informative for revealing the effectiveness of these condensers for their job of bypassing.

NOTE: A separate filament transformer must be used in the tester of Fig. 17 to maintain constant filament voltage when varying the plate voltage.

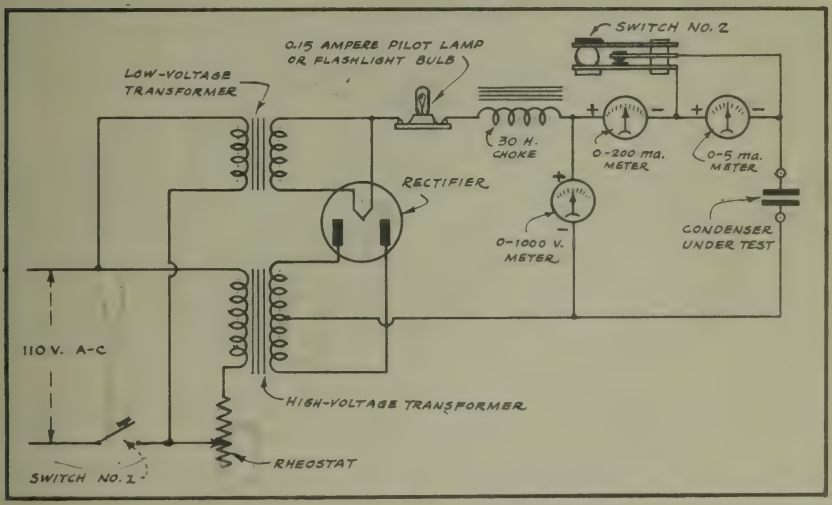

FIG. 17
CIRCUIT FOR MEASURING LEAKAGE OF ELECTROLYTIC CONDENSERS

FILTER CONDENSER REPLACEMENT

Of the common troubles which occur in the power supply of ordinary receivers, condensers constitute about 52 per cent of the necessary replacements.

Replacement filter condensers are manufactured in a great many types, sizes, and shapes. In Fig. 18 are shown a few of the common types

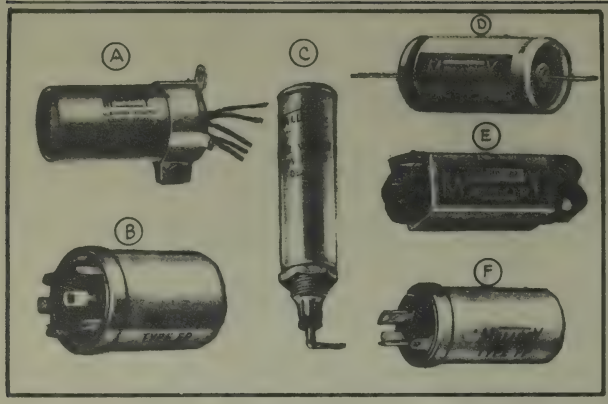

FIG. 18
REPLACEMENT FILTER CONDENSERS

manufactured by the P.R. Mallory Co., and each of which is intended for a definite application.

For instance, the type at (A) is used for replacement purposes in small and medium size a-c receivers. The type at (B) is employed in many modern combination battery and ac-dc portable receivers. (C) is a wet electrolytic type of condenser, used mainly in large a-c receivers. (D) is a small tubular type intended for ac-dc and midget a-c receivers. Condenser (E) consists of two sections of high-voltage rating, and is employed mainly in large a-c receivers. The cardboard-encased condenser at (F) is a universal type used for miscellaneous replacement.

The special condenser types (B) and (F) were designed primarily to simplify replacement. The idea was to provide filter condensers with plug-in features similar to those of vacuum tubes. Metal tongues are spaced around the edge of the metal housing in such manner that they will fit in a special bakelite socket in one position only. This automatically places the condenser terminals in the proper relation to the receiver circuits so that connections can be made conveniently. Pliers or a special wrench are used for bending the end of each tongue which protrudes through the socket, thus locking the condenser securely in place. To remove the condenser, the leads are unsoldered and the tongues are straightened again so that they will slide back through the slots in the socket.

Obviously, this method of mounting filter condensers simplifies replacement only when an exact duplicate of the original, or a similar substitute, can be obtained. If an exact duplicate or similar replacement is not available, the socket should be removed; and a condenser with a metal or cardboard case, similar to that at (A), should be installed.

The ring clamp used with the condenser illustrated at (A) of Fig. 18 makes it possible to mount this condenser in practically any position on top or underneath the chassis. In actual practice, it will be found that the four types of condensers represented by (A), (C), (D) and (E) will meet approximately 90 per cent of all replacement requirements.

There is one more important type similar in appearance to the wet electrolytic condenser illustrated at (C), but which differs from the latter in that one or more dry electrolytic cartridges are encased in a single metal housing. A special bracket is supplied for mounting this latter type of condenser. The use of this bracket allows the condenser to be mounted in practically any position.

Fiber washers are sometimes employed in mounting wet electrolytic condensers, so as to insulate the condenser from the chassis. In replacing a condenser of this type, care must be exercised to make certain

that the replacement condenser is perfectly insulated from the chassis. Sometimes, the same fiber washer as employed with the original can also be used to insulate the replacement condenser.

The proper selection of a replacement filter condenser is dependent upon several factors. The most important of these are the required value of capacity, and the d-c working voltage of the condenser. Usually, two voltages will be specified in the printed information furnished on the replacement condenser; namely, the d-c working voltage and the peak voltage. Of these, the d-c working voltage is the more important, as it specifies the d-c voltage to which this condenser can be subjected continuously without breaking down. The peak,or "surge voltage", tells us how much voltage the condenser can stand for short periods, without breaking down. Be sure to select replacement condensers of a sufficiently high d-c working voltage rating to stand up under the voltage applied to them in service.

The required capacity for the replacement condenser depends mainly on the capacity value of the original. However, in general, filtering action is greatly improved if a condenser of larger capacity is used. It will be found that most of the newer filter condensers are smaller in physical size than older condensers of equal capacity. Thus when replacements are made, it is both advantageous and feasible to substitute a condenser of rather high capacity.

NOTE: Also see your Shop Manual on "Common Radio Parts" for additional information on electrolytic condensers.

BYPASS CONDENSER REPLACEMENT

There is little to be said about the replacement of bypass condensers. The main thing to be observed in this case is that the replacement condenser be of good quality, and capable of standing up under the voltage to which it will be subjected in the receiver. That is, a condenser which is marked as having a 400 volt d-c working voltage should never be replaced by a cheaper, 200 or 300-volt condenser.

Such practice only results in destroying a service technician's reputation. And, since a good reputation must be maintained at all times, only replacements of best quality and proper voltage rating should be used.

Exact values of capacity are not always an absolute necessity when replacing bypass condensers. For instance, a 0.1 mf. screen bypass condenser will usually operate just as well in the circuit as a 0.5 mf condenser that may have been used originally.

When installing an electrolytic type condenser, it is important to connect its ground or (-) lead to the chassis (or negative side of the "B" circuit). In the case of paper condensers, the lead which is attached to the outer foil should be connected to ground or "B" minus. The end of the condenser from which this lead emerges is generally provided with some notation as "outside foil" for identification purposes.

Don't draw the wire leads of bypass condensers up too tight when connecting them in a circuit, as the application of such force may result in intermittent reception troubles later on, due to partially open condenser leads.

CERAMIC CONDENSERS: Small-capacity ceramic condensers are used in some receivers. These condensers are manufactured in sizes ranging from .00001 mf up to 0.5 mf. These condensers derive their name from the fact that their capacity elements are encased in a porcelain or ceramic tube, which provides more complete protection against heat and moisture.

Ceramic condensers can be employed as replacements, because they are approximately the same size as equivalent paper or electrolytic bypass condensers.

SILVER-MICA CONDENSERS: Silver-mica condensers are also being used. The dielectric and plate construction employed in this type of condenser has less tendency to allow changes in capacity due to expansion and contraction caused by varying temperatures. For this reason, silver-mica condensers are employed mainly as small fixed capacities in radio frequency, oscillator, and i-f circuits.

The values of silver-mica condensers seldom exceed 0.005 mf., because of the method of construction employed. Some types of these condenser are similar in appearance to the ordinary molded bakelite mica condenser. Others, instead of being flat, are rolled into the form of a small tube. On the latter type, connections are made to the condenser foils in a manner similar to that employed in the manufacture of carbon resistors; and therefore, such condensers frequently resemble small carbon resistors.

When necessary, silver-mica condensers can be replaced with ordinary molded bakelite mica condensers. However, it must be remembered that silver-mica condensers are used primarily because their capacity value remains constant under all temperature conditions. Since this is generally not true of bakelite condensers, it is always a good policy to replace a silver-mica condenser with a condenser of the same type.

NOTE: Also see your Shop Manual titled "Common Radio Parts" for additional information on bypass condensers.

REPLACING DAMAGED VOLTAGE DIVIDERS

In most cases, a burned out resistor is the result of a defect in some other part of the receiver--usually a shorted bypass condenser.

Voltage dividers generally present the most difficult problem insofar as resistor replacements are concerned. This is due mainly to the fact that the values of voltage divider resistors for each manufacture and model of receiver differ appreciably; furthermore, the resistances of the various sections of the divider are often odd values. For these reasons, it is practically impossible to obtain a replacement divider of identical electrical value, unless the part is purchased from the receiver manufacturer.

Where it is absolutely necessary to use a replacement voltage divider of identical resistance value as the original, an adjustable-tap divider such as that illustrated in Fig. 19 may be used. As many taps as are necessary can be applied to this type of divider; and the resistance sections between successive taps can then be varied to correspond with those of the original divider, merely by locking the tap sliders at the proper positions. An ohmmeter can be used to adjust the taps so that each section of the divider will furnish the needed resistance value; or, the divider can be installed and the positions of the taps then varied until the correct voltage is obtained at each tap.

In replacing a voltage divider, the new divider should have a wattage rating equal to that of the old one. And, the over-all resistance value of the new divider should be the same as that of the old one, or as near the original value as possible. If one or more sections of the old voltage divider have burned out because of some defect elsewhere in the receiver, this defect must be corrected before the new divider is installed and connected to the circuit.

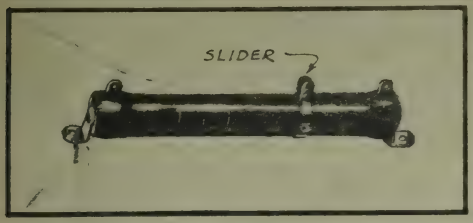

FIG. 19
ADJUSTABLE VOLTAGE DIVIDER

Brackets are generally supplied for mounting replacement dividers; the usual method being to mount the voltage divider in a horizontal position, as shown in Fig. 19.

"BRIDGING" DEFECTIVE VOLTAGE DIVIDER SECTIONS: So far, we have assumed that the complete divider is being replaced. However, instead of replacing the entire divider, it is generally possible to "bridge" the open or burned out section with a wire-wound resistor, as shown in Fig. 20. In certain cases, this method is preferable to replacing the complete divider, even when it is necessary to "bridge" more than one damaged section. The value of the bridging resistor must, of course, be equal to that of the divider's open resistance-section across which it is connected; and its wattage rating must be adequate for the load handled.

In selecting a replacement resistor of any kind, special attention must be given to the wattage-rating of the resistor. In the average receiver, one or more sections of a voltage divider may have to dissipate as much as 40 or 50 watts of power. Therefore, the maximum amount of current which the resistor will have to carry must be determined before selecting a replacement. The procedure in this case is to ascertain the total current flow through the resistance in question by analyzing the circuit arrangement. The required wattage-rating can then be calculated easily by applying the formulas given in an earlier Manual on "Common Radio Parts".

INDIVIDUAL RESISTORS

The trend, today, is to use insulated resistors of 1/4, 1/2, and 1 watt sizes. In the majority of receivers the 1/2 watt and 1/4 watt sizes are adequate, except in audio output and power supply circuits where greater currents flow through them.

In the past, the tendency was to employ resistors of 1 watt or larger size throughout the receiver. For this reason, the comparatively small size of the resistors used in modern receivers sometimes surprises a serviceman, and he is often likely to assume that a particular trouble is due to the use of resistors of too low wattage-rating. This may not necessarily be true, because the current flow through the resistor in question perhaps does not exceed 2 or 3 milliamperes. Since the voltage-drop across these resistors is usually small, it is evident that a 1/2 watt resistor can safely handle the required wattage dissipation.

A receiver manufacturer will often use resistors of a wattage-rating that is exactly equal to the actual wattage to be dissipated or

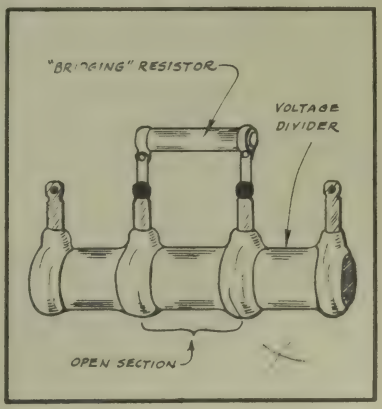

FIG. 20
"BRIDGING" BURNED-OUT VOLTAGE DIVIDER SECTION

even slightly under the minimum value that should be used. This is sometimes done to reduce the cost of manufacture, as resistors of lower wattage-rating are cheaper. Any slight overload or short in the circuit in which an under-rated resistor is used will immediately cause the resistor to burn out. In cases where it is evident that the use of under-rated resistors has been the practice, the damaged resistor should be replaced by one of higher wattage value.

Ordinary commercial resistors usually have a tolerance of 10 per cent above or below the specified value. That is, the actual resistance value of the resistor may be as much as ten per cent higher or lower than the specified value. In an ordinary radio circuit, this much variation will make practically no difference in the operation of the receiver; and therefore the use of resistors of greater accuracy is not necessary.

Resistors of doubtful condition should be checked by applying an ohmmeter across their terminals and comparing the actual resistance reading with the value specified by their color coding. Be sure that the resistor being measured is disconnected from all receiver circuits during this test.

NOTE: Also see Manual titled "Common Radio Parts" for additional information concerning resistors.

VOLUME CONTROL REPLACEMENTS

Volume controls often become defective in time. They may be responsible for intermittent reception, noisy reception, or may cause the receiver to be completely inoperative. Sometimes, a grating sound is heard as the volume control knob is turned in either direction.

When replacing a defective volume control, be sure to select one of the same type (wire or carbon), and of the same resistance value as the original. It is also important, in certain cases, that the replacement volume control have the same taper characteristic as the original, and that its physical dimensions be such as to permit convenient mounting.

Also note whether or not the power switch is to be mounted on the volume control, and order the replacement unit accordingly. Notice further whether or not the volume control in question is provided with a special tap for tone compensation so that this feature will also be included in the replacement unit, when necessary.

Volume controls, and potentiometers in general, are described thoroughly in your Manual titled "Common Radio Parts" and also in one of your regular lessons titled "Volume and Tone Controls". Therefore, nothing further need be mentioned at this time.

REPLACEMENT I. F. TRANSFORMERS

The replacement of i-f transformers is not a difficult job. Mostly, it is a matter of obtaining a replacement unit of correct frequency-rating. Several other factors which are of secondary importance include the following: the value of coupling between the tuned coils of the transformer; the amount of gain that will be obtained at the correct i-f frequency; the selectivity of the transformer.

In ordinary practice, the gain and selectivity of an i-f transformer cannot be determined without considerable work and precise measurements. Therefore, in most cases, the gain and selectivity will not be specified for a given receiver. However, the i-f transformers that are obtainable from radio supply houses are of average gain and selectivity, and are therefore suitable for general replacement purposes.

Replacement i-f transformers are usually listed in manufacturers catalogs according to their tuning range, and the stage in which each type of i-f transformer is to operate. That is, specifications will state whether the unit in question is an input i-f transformer, and interstage i-f transformer, or a diode-input i-f transformer (output i-f transformer). The average receiver usually has only two i-f transformers --an input transformer and a diode-input (output) transformer. It is important that the replacement be of the proper type in order to operate correctly in the stage in which it is to installed.

Quite often, a different type of i-f transformer can be substituted in place of an ordinary replacement. For instance, it may be that a high gain is desired in one stage of the receiver's i-f section; in which case an iron-core permeability-tuned transformer would be suitable. However, in general, it must be remembered that as the gain increases in an i-f stage, so also does the selectivity; and, it is not always desirable to increase gain at the expense of tone quality. But, if tone quality is not important, then the use of high-gain i-f transformers will often improve the performance of a receiver insofar as sensitivity is concerned.

Most i-f transformers are provided with color-coded leads for connection to the tube socket terminals and other parts of the circuit. In some types of i-f transformers the leads terminate at soldering lugs; and when mounted on the chassis, these soldering lugs protrude downward through the chassis. Various other parts, such as resistors, bypass condensers, etc., are then soldered to these lugs. This eliminates the need for tie-posts or extraneous terminals on the underside of the chassis.

If the i-f transformer is to operate into a tube that has its control grid connection on top, one lead is brought out through the top of the shield can. For single-ended tubes, all leads of the i-f transformer are brought out through the opening at the bottom of the shield can.

When replacing an i-f transformer, select one which corresponds as closely as possible to the original. This applies to both physical and electrical characteristics. In regard to physical characteristics, the method of mounting is most important; that is, to facilitate matters, the replacement should have the same mounting provisions as the original. However, this is sometimes impossible because the methods of mounting adopted by different manufacturers vary somewhat.

Practically all standard replacement i-f transformers are equipped with spade bolts which are riveted to the shield can. These spade bolts fit in holes drilled in the chassis, and are held tight by nuts screwed on their ends which protrude through the chassis. Thus, it is possible that new holes in the chassis may be necessary before the new transformer can be mounted.

The leads of replacement i-f transformers are generally color coded according to the point or terminal to which they must be connected. In the case of input or interstage transformers, the color code is as follows:

Plate lead----------blue
B+ lead----------red
Ground, or a-v-c lead----black
Control grid----------green

The lead colors of diode - input (output) i-f transformers are the same, with the exception that the black lead is connected to the diode load resistor, and the green lead to the diode plate or plates. In certain cases, however, the diode plate lead may be white to differentiate

it from a grid lead. On some i-f transformers having a center-tapped secondary, the center-tap lead is black; and the second diode plate lead is green-and-black striped. A color-code table is usually provided with replacement i-f transformers to simplify their connection to the circuit.

TESTING AIR-CORE COILS

Air-core coils such as r-f transformers, i-f transformers, r-f chokes, etc., can be tested by applying an ohmmeter across the winding terminals in the same manner as described earlier in this Manual for testing iron-core coils. However, the resistance of such windings is sometimes appreciably less than that of windings having a laminated steel core.

If the winding is open, the ohmmeter will indicate infinite resistance. A good winding will cause the ohmmeter to indicate a resistance value equal to that specified for the coil by the manufacturer (sometimes stated on the factory diagram of commercial receivers). If the correct resistance value is not known, check through another similar coil on the receiver and compare values. (Often, there are two or more identical coils in a receiver--such as similar r-f coils, i-f coils, etc., so that such a comparative test is possible). In all cases, however, be sure that the winding being tested is disconnected from all circuits; otherwise, the meter readings may lead to erroneous conclusions.

If no ohmmeter is available, a d-c voltmeter connected in series with a battery can be used as a continuity tester as described earlier in this Manual for checking iron-core coils.

REPLACING R-F TRANSFORMERS (COILS)

In most cases, r-f coil replacements are necessary due to physical damage to the coil, or to a defect which occurred during the manufacture of the coil. However, burn-outs sometimes also occur. Coil replacements cannot usually be affected by means of standard coils obtainable from radio supply stores. However, standard types of coils are used in some receivers; but this practice is confined mostly to small t-r-f or midget superheterodynes.

For receivers which do not employ standard types of coils, an exact coil replacement must be obtained from the factory or its distributor agent. But before a new coil is ordered, the damaged or defective one should be thoroughly examined to see if it can be repaired. Very often, the trouble is due to a poorly soldered connection, or to a broken wire at the point where it is fastened to a soldering lug. In such cases, it is a simple matter to re-solder the wire to the lug, or to splice the broken wire.

The copper wire of the coil winding sometimes corrodes, particularly in damp climates. This corrosion may occur in one or two spots on the winding, and usually seems to develop more in coils which are carrying r-f current. Thus, if the oscillator section of a receiver goes dead, the oscillator coil should be inspected for possible corrosion at some point.

If only one point on the winding is affected by corrosion, it is often possible to repair the damage. All that is necessary, in this case, is to carefully lift up the broken ends of the wire, clean them thoroughly, and then drop them back into place. The ends can then be bridged by carefully applying solder, as in Fig. 21. (Be careful not to short several turns together while doing this).

A better method is to unwind one turn of wire and thoroughly clean the two ends. The ends can then be twisted together and soldered. Of course, this will reduce the inductance of the coil, but usually not enough to prevent realignment of the circuit by means of the trimmer condenser.

If a coil cannot be repaired satisfactorily in an all-wave type receiver, an exact duplicate must be obtained from the receiver manufacturer. Substitute coils cannot be used in this type of receiver. Even installing an exact duplicate coil in an all-wave receiver presents quite a problem, as in many such cases the complete coil assembly must be dismantled before the new coil can be installed.

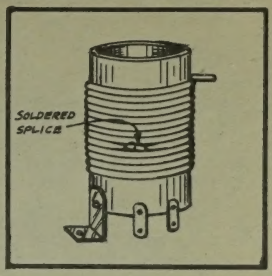

FIG. 21
REPAIRED R-F COIL

REPAIRING BAND-SELECTOR SWITCHES

In most cases, where this switch cannot be repaired, it is necessary to replace only one section of the switch assembly. This necessitates disconnecting all of the wires which are attached to the various terminals of the affected switch section.

If the defective section is located toward the front portion of the switch assembly, it may be necessary to completely remove all of the wiring in that section before the defective part can be replaced. Therefore, before such a replacement job is even commenced, a detailed description of the switch terminal connections should be noted in writing. Also, a simple pictorial drawing should be made to show how each connection is made. This must be done to prevent connection errors and to save time.

The same precautions are necessary when replacing a defective coil. That is, a drawing should be made of the coil, showing the insulation color and approximate location of the various leads. Then, when the replacement coil is installed, the new connections can be made without having to trace out each individual circuit.

Band-selector switch troubles are mechanical in nature, and the best way to correct them will be apparent upon examination. One of the most common complaints is failure to provide good contact when the switch is closed to a certain position. Bending one of the contact fingers a little will sometimes help to correct this condition.

To determine if a certain circuit is completed satisfactorily by the switch, test for continuity between the terminals involved--using an ohmmeter, or d-c voltmeter connected in series with a battery. In Fig. 22, for example, the switch, when in the position shown, supposedly is connecting together terminals No. 1 and No. 4. Therefore, the ohmmeter should indicate zero resistance when connected across these two terminals; and the voltmeter, if used, should read battery-voltage.

So as to be sure that you are testing only through the switch, and not through a coil or other circuit which is connected to the terminals involved, unsolder the leads from the terminals before making the test.

SPEAKER REPLACEMENTS

Speakers have become as much standard equipment as have power transformers. The usual practice is to replace only the defective portions of

a speaker--such as the cone, the field, or output transformer. Usually, if it is necessary to replace two parts at a time--as, for instance, the speaker cone and field--it is better to install a complete new speaker, because it can usually be purchased for the same amount of money as it would cost to replace the two parts in the old speaker.

In selecting the new speaker, the following three points are of importance: The speaker field should have the same resistance as the original; the frame-size should be approximately the same (exactly the same as to distance across the speaker cone unless adequate space is available); and the voice coil or output transformer must have the same impedance-rating as the original. This matter of speaker selection and repairing is covered thoroughly in one of your regular lessons on "Dynamic Speakers", and need therefore not be discussed further at this time.

Sometimes, it is necessary to lengthen the wires leading to the speaker by splicing additional lengths to them. In cases where the old speaker was connected to the chassis by means of a cable and plug, the cable can be cut off close to its termination at the old speaker and then connected to the new speaker.

The R.M.A. color code for loudspeaker leads is as follows:

Voice Coils:
Green and black----------Start lead
Green----------Finish lead

Field Coils:
Black and red----------Start lead
Yellow and red----------Finish lead
Slate and red----------Tap lead

MISCELLANEOUS REPLACEMENTS

In the event that it becomes necessary to replace damaged tube sockets, always use sockets of good quality. High-resistance connections often result from tubes not fitting cheap sockets properly.

Useful information on radio wire is given in your Manual titled "Common Radio Parts". It is suggested that you refer to this Manual when confronted with problems involving conductor replacements.

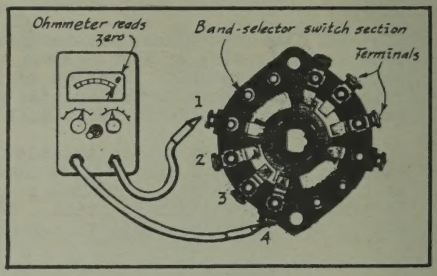

FIG. 22
TESTING BAND-SELECTOR SWITCH

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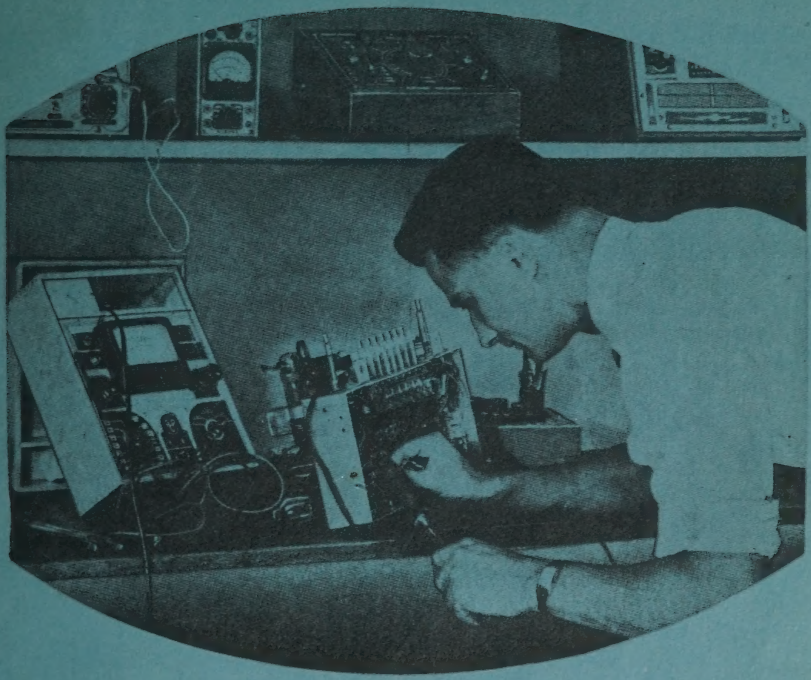
VA
Srećno sam gaja



Intelligent use of proper testing equipment enables the technician to locate the defective part quickly.

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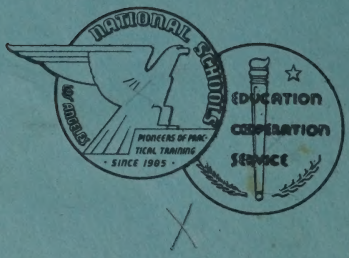
Correct selection of the replacement part safeguards against recurrence of the same trouble.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